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Smart Public Toilet Management and Monitoring System using IOT

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Abstract: *This paper addresses the pervasive issue of inadequate public sanitation in various regions of India and slums, marked by rampant urination and poorly maintained public toilets. Despite significant governmental expenditure and efforts to maintain cleanliness, the absence of a centralized monitoring mechanism renders these endeavors ineffective. To overcome this challenge, the paper proposes an Internet of Things (IOT)-based toilet monitoring system utilizing a web server and a mobile cleaner application. The system aims to simplify monitoring processes for toilet cleaners and administrators by tracking multiple cleaning metrics and providing real-time alerts based on user input. The motivation behind this project stems from the alarming state of hygiene in government schools, where students or teachers often bear the responsibility of cleaning due to labor shortages and insufficient funds. The relevance of the proposed system lies in its potential to revolutionize the maintenance of school and public toilets, addressing the unhygienic conditions prevalent in India. The novelty of the system includes features like automatic water flush, UV sanitization, timely floor cleaning, automatic sanitary pad vending, water monitoring, smell detection, and automatic ventilation, all facilitated through IOT technology. By presenting a cost-effective and efficient solution, this research contributes to the improvement of public sanitation in various settings, including homes, schools, colleges, hospitals, businesses, and industries, thereby promoting urban sanitation in the contemporary environment.*

Keywords: sanitation, public toilets, government school, hygiene, automatic water flush , data monitoring, real time tracking.

I. INTRODUCTION

The introduction to this research delves into the multifaceted challenge of public sanitation in India, emphasizing the persistent issues of inadequate facilities, rampant urination, and poorly maintained public toilets in various regions and slums. Despite commendable efforts and considerable financial investments by the government to ensure cleanliness, a crucial gap exists due to the absence of a centralized monitoring system. The backdrop of this problem is set against the backdrop of staggering statistics provided by UNICEF, which reveal that India faces the highest rate of exposure to human waste, with an estimated 625 million people lacking access to toilets. Such a dire scenario poses severe public health risks, necessitating innovative solutions to address the root causes of unsanitary conditions.

The Swatch Bharat Mission Urban, established under the Department of Housing and Urban Development, has made noteworthy progress in constructing functional toilets across Indian cities. However, despite the existence of over 5.1 lakh functional toilets and public facilities, the prevalence of open defecation remains a critical concern. This paper contends that the conventional approaches to public toilet cleanliness are insufficient, as the lack of a centralized monitoring mechanism undermines the effectiveness of various initiatives. It emphasizes the need for a transformative solution that not only addresses the existing sanitation challenges but also prevents the degradation of public toilets in the long run.

One of the focal points of concern is the deplorable state of sanitation in government schools. The paper highlights a startling practice where students or teachers are compelled to clean toilets due to labor shortages and insufficient funds for cleaning staff. This absurdity underscores a broader issue, raising questions about the efficacy of existing sanitation policies and the need for an innovative and sustainable approach. The introduction posits that the relevance of the

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proposed solution lies not only in its potential to revolutionize the maintenance of school and public toilets but also in its broader applicability to diverse settings, including homes, colleges, hospitals, businesses, and industries.

The overarching objective of this research is to introduce and advocate for an Internet of Things (IOT)-based toilet monitoring system. This proposed system aims to bridge the existing gap in centralized monitoring by leveraging IOT technology, incorporating a web server and a mobile cleaner application. By doing so, the system facilitates real-time tracking of various cleaning metrics, providing a comprehensive overview of the condition of public toilets. The innovative nature of this system lies in its ability to streamline the monitoring process, alerting both toilet cleaners and administrators about the status of toilets based on user input.

The paper underscores the novelty of the proposed IOT-based system, enumerating features that set it apart. These features include automatic water flush and UV sanitization, timely floor cleaning, an automatic sanitary pad vending system, water monitoring, smell detection, and automatic ventilation. By integrating these advanced functionalities, the system aspires to be a game-changer in the realm of public sanitation, offering not just a monitoring solution but a comprehensive approach to improving hygiene and cleanliness.

In conclusion, the introduction sets the stage for a comprehensive exploration of the public sanitation challenges in India and proposes an innovative solution through an IOT-based toilet monitoring system. By addressing the inadequacies in current approaches and introducing advanced features, the paper aims to contribute to a paradigm shift in how public toilets are monitored and maintained, ultimately promoting higher standards of cleanliness and hygiene across various sectors.

II. LITERATURE REVIEW

Amar Lokman et al. [1], this paper "Scheduling and Predictive Maintenance for Smart Toilet" presents an innovative approach to addressing challenges in bathroom facilities through the implementation of an Internet of Things (IOT) administration platform. Focusing on enhancing smart toilet facilities, the study integrates various sensors, including infrared, temperature, and humidity sensors, to create a smart toilet environment. The research evaluates predictive maintenance models, comparing Auto-Regressive Integrated Moving Average (ARIMA) and Long Short-Term Memory (LSTM) for equipment breakdown forecasting. Additionally, the paper introduces a scheduling algorithm, utilizing a genetic algorithm to optimize janitorial staffing. The methodology involves system design, hardware and software requirements, and algorithm analysis. By addressing potential concerns such as privacy and wetness issues, the paper emphasizes the advantages of optimizing resource utilization, minimizing wastage, and cutting costs. The study contributes valuable insights into the integration of IOT, predictive maintenance, and scheduling for efficient and improved smart toilet facilities.

Panel Dheeraj Kumar et al. [2], this paper introduces a novel approach to elderly care through the deployment of intelligent IoT-driven smart toilets designed for home-based health monitoring, with a particular emphasis on early detection of viral infections like COVID-19. The proposed Multi-scaled Long Short Term Memory (Ms-LSTM) model employs the Internet of Things (IoT)-Fog-Cloud paradigm, utilizing a four-layered architecture for data acquisition, localized processing, extensive analysis, and user interface. The model's efficiency is validated against state-of-the-art methods, demonstrating superior performance in terms of mean temporal efficiency, reliability, stability, and predictive accuracy. The comprehensive methodology showcases the integration of advanced technologies, providing a layered and non-intrusive approach to health monitoring. While the paper highlights innovation, it could benefit from deeper discussions on ethical considerations, privacy concerns, and user acceptance, as well as practicality and affordability, to ensure the potential real-world for elderly healthcare.

Adrian B et al. [3], this paper discusses the development of an "IoT Based Cubicle Occupancy Indicator" to address challenges in public restrooms, especially in the context of the COVID-19 pandemic. The methodology involves leveraging IoT technology with a Passive Infra-Red (PIR) motion sensor, Arduino Uno microcontroller, and an IoT server to automate and communicate cubicle occupancy status. LED lights at the restroom entrance relay real-time information to users, reducing the need for physical checks and promoting a more hygienic environment. The system aims to enhance user experience, minimize unnecessary contact, and contribute to a safer and more efficient public restroom experience. While the paper presents an innovative solution, considerations such as IoT infrastructure reliability, privacy concerns, and cost implications should be addressed for widespread adoption. Despite potential limitations, the proposed system offers a valuable contribution to improving restroom accessibility and maintaining public health measures.

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Carnovale et al. [4], "Policy Guidelines for Smart Sanitation Technology as a Public Health Tool," explores the emerging realm of Smart Sanitation Technology (SST) and its applications in the sanitation industry. Focused on providing a policy framework for the responsible use of SST, the paper applies fundamental principles such as scientific evidence, necessity, proportionality, time boundedness, and privacy. It highlights the potential of SST as a crucial public health tool, especially in the context of the COVID-19 pandemic, where applications include sewage monitoring for disease data and epidemiological analysis. The methodology combines a review of existing applications with a principled approach to ensure ethical and responsible deployment of SST, considering the sensitive nature of health data collected. While advantageous for its comprehensive overview and timely insights, the paper could benefit from offering more concrete solutions or guidelines to address ethical concerns associated with SST, providing actionable insights for policymakers and implementers.

Raiful Hasan et al. [5], this paper introduces FinderX, a Bluetooth beacon-based system designed to improve urban trash management in the context of smart cities. It focuses on enhancing accessibility to city amenities, particularly for individuals with visual impairments. Utilizing Bluetooth Low Energy (BLE) beacons, FinderX provides real-time location information within a 100-meter radius, transmitting signals to smartphones for directions to nearby amenities. Notably, the system operates both indoors and outdoors without relying on GPS or internet infrastructure. Extensive testing demonstrates FinderX's feasibility, showing an average 18.98% reduction in the time needed to locate a nearby trash bin. The advantages include improved accessibility, versatility, and scalability through cloud technology, while challenges include issues in test deployment, accuracy in crowded environments, and concerns about battery life. The paper suggests future work to address these challenges and enhance FinderX's applicability in diverse urban settings.

Dr. Prasanjeet Patil et al. [6], this paper investigates futuristic technologies aimed at enhancing public toilet facilities within the framework of smart cities, addressing prevalent concerns regarding cleanliness and hygiene. The research methodology entails a thorough exploration of innovative approaches, such as the Internet of Things (IoT), image processing, and energy conservation techniques, to revolutionize the design and functionality of public toilets. By focusing on the intersection of technology and environmental considerations, the paper aligns with the broader goals of sustainable urban planning and contributes to the Swachh Bharat Mission in India. It delves into the potential of smart city initiatives in managing water, waste, and energy consumption, offering a holistic perspective on urban development. While the paper introduces valuable insights, a more detailed discussion on practical challenges, cost implications, and public acceptance, as well as empirical evidence or case studies, could enhance its depth and applicability. Nonetheless, the research serves as a commendable starting point for the integration of technology to address sanitation challenges in the evolving landscape of smart cities.

Farzana Shaikh et al. [7], this paper titled "Smart Toilet Based On IoT" introduces an innovative solution to sanitation challenges in India through a smart toilet management system leveraging IoT technology and various sensors. The proposed system aims to promote cleanliness and hygiene by incorporating modules such as User Detection, Dirt Detection, Smell Sensing, Monitoring Sweeper's Activity, and Water Conservation. The methodology involves the integration of IR, smell, sonic, and RFID sensors, but lacks detailed exploration of implementation steps, testing procedures, and real-world validations. Advantages include automation for a cleaner restroom experience, environmental sustainability through water conservation, and user awareness. Concerns about sensor accuracy, privacy issues, user acceptance, and the need for technical support pose challenges that need careful consideration for successful implementation.

Yang Jing Wei Hongyan et al. [8], this paper titled "Design and Implementation of Urban Intelligent Public Toilets in the Big Data Era" presents an innovative system aimed at addressing challenges in urban public toilets to enhance overall quality of life. Operating in a closed loop, the platform utilizes big data cloud technology for real-time intelligent control of urban public toilets. The design objectives include creating a comfortable and intelligent toilet environment, effective equipment management, real-time scheduling for toilet superintendents, and enhancing emergency response capabilities. The system incorporates wireless communication technologies such as Zigbee (LoRa), 5G, and WIFI, utilizing intelligent gateways, sensors, and control equipment. Various subsystems, including spot monitoring, broadcasting, paper-taking, monitoring, and supervision, contribute to a holistic approach to intelligent public toilet management.

Klaiwad Boonyakan et al. [9], this research paper introduces a water-efficient automatic toilet flushing system designed to optimize cleanliness and conserve water. Utilizing IOT technology, the system incorporates sensors for user presence detection and a solenoid valve for automated water release. Over a three-month experiment involving 100 male users, the study determines that a flushing duration of approximately 3.8 seconds strikes an effective balance between hygiene and water efficiency. The hardware components include an ESP8266 microcontroller, an infrared sensor, and the solenoid valve. The paper emphasizes the implementation of IOT solutions in everyday contexts, in improving toilet systems and offers valuable analysis of user behavior, for optimizing flushing parameters. While addressing water conservation in public toilets,

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the study guides towards prospective areas for future researchsuch as exploring demographic variations in user behavior and preferences. The findings support the growth, of water-efficient and user-friendly automated toilet systems, but limitations include a specific user demographic focus and a requirement for additional exploration of, water volume considerations and cultural factors influencing user behavior.

D Kristiyani et al. [10], this research paper aims to enhance the privacy and safety of women in public restrooms, specifically addressing concerns in developing countries like Indonesia. The methodology involves the creation of a comprehensive gender-annotated image dataset, emphasizing diversity in facial features and expressions. The research introduces a Facial Recognition Model based on Convolutional Neural Networks (CNN) to automatically detect gender through webcam feeds. This model can be integrated with a security alarm system for real-time gender detection, contributing to the prevention of unauthorized access and ensuring the security of women in public restroom areas. The research acknowledges the advantages of improved privacy, safety, efficiency, and automation but emphasizes the need to address ethical considerations, potential biases, and financial implications for responsible implementation in public spaces.

D Purkayastha et al. [11], this paper delves into the critical issue of inclusion in public toilets in urban India, addressing the varied challenges confronted by diverse demographic groups. Utilizing global perspective, it conducts a thorough examination of existing models for studying inclusion, assessing their adaptability to the unique context of Indian cities. The paper commendably recognizes ongoing initiatives, such as the Swachh Bharat Mission, in tackling public sanitation challenges while maintaining a balanced viewpoint. However, it could further strengthen its arguments by incorporating specific case studies illustrating the challenges faced by vulnerable groups. Additionally, the focus on urban India might limit the generalizability of findings to rural areas. Despite these considerations, the paper serves as a catalyst for future research, emphasizing the necessity for context-specific studies and promoting a nuanced understanding of inclusion in public toilets within the Indian urban landscape.

Sonaly Rezende et al. [12], the systematic review explores the significance of on-street public toilets in urban sanitation, aiming to identify knowledge gaps and guide future research. Emphasizing the indispensability of sanitation in public spaces for universal access, particularly for vulnerable groups, including women, transgender individuals, children, the elderly, and people with disabilities, the paper underscores the need for further research, inclusive engagement, and adherence to the normative policy framework outlined by the United Nations. The literature reveals diverse perspectives on solutions, pointing to the importance of a comprehensive approach in addressing sanitation challenges in urban areas. The paper serves to increase awareness of the pivotal role of on-street public toilets in fostering safe, accessible, and inclusive urban environments.

Emma Rary et al. [13], "Smart Sanitation—Biosensors as a Public Health Tool in Sanitation Infrastructure," explores the application of biosensors in sanitation infrastructure for improved public health monitoring. The authors identified 21 relevant papers focusing on biosensor use in toilets, sewage pipes, and septic tanks. The biosensors are used monitoring drug usage, virus screening, and diagnosing conditions like diabetes. The majority of the studies were nonrandomized, small-scale pilot or lab studies. Among the identified biosensors, 11 collected population-level data, seven provided real-time continuous data, and 14 were deemed more cost-effective than traditional surveillance methods. The paper emphasizes the potential of biosensors in Smart Sanitation to enhance health monitoring at both individual and community levels. While acknowledging the strengths of the research, such as its timeliness and a comprehensive literature review, the paper also recognizes limitations, including the early stages of development in many studies and potential biases from relying on various types of literature. The authors highlight the imperative for additional investigation and analysisto address methodological and ethical considerations, ensuring the reliability and applicability of biosensor findings in the evolving field of Smart Sanitation.

Raendran et al. [14], this paper investigates the application of Internet of Things (IOT) technology in facilities management through a Smart Toilet system. Conducted by researchers from Multimedia University Cyber jaya, Malaysia, the study focuses on understanding individual end users' perceptions of the proposed Smart Toilet and its associated app. A comprehensive online survey involving 124 participants forms the basis for data collection. Employing statistical analysis methods, the research examines user experiences, preferences, and attitudes towards the Smart Toilet technology. The study emphasizes a user-centric approach, aligning with the Theory of Planned Behavior, and employs both descriptive and inferential statistics to interpret results effectively. The paper introduces an innovative Smart Toilet system architecture, utilizing motion sensors, automated scheduling, and predictive maintenance for resource optimization in facilities management. While the paper imparts valuable perspectives on IOT-based Smart Toilet systems, it has limitations, including a lack of detailed exploration of challenges, insufficient discussion on ethical implications, and potential biases

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from relying on an online survey. Nevertheless, it contributes significantly to the understanding of IOT applications in facilities management and provides a foundation for future research and implementation.

Sevangthi Murthy et al. [15], this paper explores the implementation of an Internet of Things (IoT) system in Smart Toilets with a focus on optimizing janitorial resources. The proposed architecture emphasizes the utilization of cloud technology for flexibility and manpower resource optimization. The IoT system, spanning from sensors to a cloud-based data management system, aims to streamline janitorial services, reduce unnecessary cleaning efforts, and contribute to overall resource conservation. The methodology involves a systematic approach, starting with the identification of challenges in current janitorial services, followed by a comprehensive literature review on IoT applications in smart cities and buildings. Practical implementation includes the strategic deployment of sensors, a robust communication infrastructure, and algorithm development for real-time data analysis. Advantages include potential cost savings, flexibility, scalability, and a holistic approach to toilet maintenance. However, challenges include initial costs, technical complexities, data security and privacy concerns, potential resistance from stakeholders, and the reliance on accurate data interpretation for optimal resource allocation. Balancing these factors is crucial for assessing the feasibility and acceptance of the proposed IoT implementation in Smart Toilets within the broader context of facility management.

Krithika S et al. [16], this paper proposes an IoT-based system, named "NAMMA TOILET," for continuous monitoring and improvement of cleanliness conditions in public toilets. Aligned with the "Swachh Bharath" (Clean India) project, the system incorporates proximity sensors, biometric authentication, gas sensors, and a dashboard for monitoring and storing cleaner activity data. Leveraging IoT concepts and Big Data Analytics, the system autonomously flushes, detects cleanliness levels, and mitigates odors. The methodology involves integrating various hardware components and software programming, including microcontrollers, sensors, motors, RFID, biometric systems, GSM modems, and Big Data analytics. Advantages include improved toilet usage, accessibility for tourists, reduction in open defecation, disease prevention, preservation of sweeper jobs, and maintenance of good odor. However, potential disadvantages include susceptibility to technical failures, high setup and maintenance costs, and privacy concerns related to biometric and RFID systems.

Intan Soraya Rosdi et al. [17], this paper presents a Smart Toilet system designed to enhance facilities management through the integration of motion sensors, automated janitor scheduling, and predictive maintenance, complemented by a dedicated mobile app. The study, involving 124 respondents through an online survey, focuses on comprehending end users' perceptions of the proposed technology. The methodology encompasses a thorough analysis of related works, system architecture, and a user perception study based on the Theory of Planned Behavior. The advantages of the Smart Toilet system include optimizing resources, improving user experience, and aligning with international standards. However, concerns arise regarding privacy and data security, given the implementation of IoT technology in public facilities. The reliance on cloud technology introduces dependencies on external servers, posing potential risks in the event of disruptions or security breaches.

Andi Pramono et al. [18], this paper discusses the implementation of smart mechanical ventilation and artificial lighting in the men's toilet on the second floor of Bina Nusantara University in Jakarta, Indonesia, with a focus on enhancing energy efficiency. The research, conducted by Andi Pramono, Tiara Ika Widia Primadani, and M. Aldiki Febriantono, integrates insights from interviews with building operators and cleaners, along with on-site surveys, to understand the existing conditions and challenges in the restroom. To address the ventilation system, the authors use interview data to tailor a customized mechanical ventilation solution, employing an exhaust fan. The lighting conditions are evaluated using a lux meter, ensuring compliance with established standards for brightness and color temperature. The paper emphasizes the integration of technology, specifically the use of Arduino Mega and sensors, to automate electrical devices for energy efficiency. While the research contributes valuable findings regardingrestroom challenges and proposes practical solutions, such as automation for energy conservation, it has limitations in terms of generalizability, scalability concerns, and a lack of exploration into user experiences and long-term system effectiveness. Despite these limitations, the paper contributes to the understanding of improving energy efficiency in restroom facilities through smart technologies.

Nidhi R Mishra et al. [19], this paper titled "Smart Toilets using BLE Beacon Technology" explores the incorporation of Bluetooth Low Energy (BLE) beacon technology into a Smart Toilet system for efficient public toilet management. The system aims to address challenges related to toilet availability, cleanliness, and behavioral change. BLE beacons and readers are deployed to track user behavior, promoting positive changes in toilet usage. The methodology involves the implementation of BLE beacons and readers, utilizing the iBeacon protocol, and a combination of broadcast and mesh topology of Bluetooth. The system integrates various software components and hardware requirements for effective public toilet management. Advantages include technological advancement, enhanced efficiency, and reliability due to BLE beacon

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lifespan. However, the paper lacks a detailed discussion on potential limitations, scalability, and real-world testing, requiring further research to validate its practicality and effectiveness.

III. LITERATURE SUMMARY

Sl. No	Citation	Year	Methodology/Algorithms used	Remarks
1.	AMAR LOKMAN, R. KANESARAJ RAMASAMY, (Senior Member, IEEE), AND CHOO-YEE TING	2023	The methodology involves system design with MQTT and HTTP for data transfer, hardware implementation with Raspberry Pi and Arduino TTGO, and algorithm analysis for scheduling and predictive maintenance.	The paper innovatively integrates IoT for smart toilet management, showcasing potential benefits. However, it lacks a detailed real-world assessment. Emphasizing system limitations and user feedback would enhance its practicality
2.	panelDheeraj Kumar a, Sandeep Kumar Sood b, Keshav Singh Rawat	2023	The methodology involves developing and implementing a Multi-scaled Long Short Term Memory (Ms-LSTM) model for home-based health monitoring, integrating the Internet of Things (IoT)-Fog-Cloud paradigm and evaluating its performance against state-of-the-art methods.	This innovative approach, employing IoT-driven smart toilets and Ms-LSTM model, shows promise for elderly health monitoring. However, ethical considerations and practicality in diverse contexts need deeper exploration.
3.	Adrian B. Alfonso, Rainier C. Atizado, Angela Mae V. Encinas, Deanne Marie Nivera, Leanne Kirsten G. Samala, Dr. Eric Blancaflor	2023	The study implements an "IoT Based Cubicle Occupancy Indicator" utilizing IoT technology, PIR motion sensors, Arduino Uno microcontroller, and an IoT server to enhance public restroom efficiency.	This innovative IoT-based Cubicle Occupancy Indicator effectively addresses public restroom challenges during the pandemic, promoting safety and efficiency. The system's simplicity and real-time information provision make it a promising solution for enhanced user experience
4.	Carnovale and Maria year	2022	The methodology involves developing a policy framework for Smart Sanitation Technology (SST) by applying principles such as scientific evidence, necessity, proportionality, time boundedness, and privacy.	It is IOT based smart toilet and it evolves landscape of Smart Sanitation Technology (SST) and its applications, highlighting the need for a principled policy framework. However, it could enhance impact by offering more concrete solutions to ethical concerns.
5.	Raiful Hasan Ragib Hasan.	2022	The methodology involves designing and deploying Finder X, a Bluetooth beacon-based system, emphasizing inclusivity and accessibility for improved urban trash management.	Finder X presents a comprehensive solution for urban waste management employing Bluetooth beacons, showcasing an 18.98% reduction in locating time. Challenges include signal accuracy in crowded areas and potential limitations in functionality.
6.	Dr. Prasanjeet Patil, Dr.Nilesh Bahadure, Uma Pujari	2022	The methodology involves exploring innovative technologies (IoT, image processing, energy conservation) for smart toilets, addressing cleanliness challenges in public facilities within the context of smart cities.	This paper adeptly examines futuristic technologies for smart toilets in the realm of smart cities. While emphasizing ecological aspects, it offers promising insights, yet practical challenges and real-world implementation considerations warrant deeper exploration.

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7.	Farzana Shaikh	2021	The methodology involves designing and implementing an IOT- based Smart Toilet, integrating various sensors for user detection, dirt sensing, smell detection, sweeper monitoring, and water conservation modules.	The Smart Toilet system, while innovative, faces challenges such as sensor reliability, privacy concerns, and the need for user cooperation. Clear communication and addressing technical issues are vital for successful implementation and sustained impact.
8.	Yang Jing Wei Hongyan	2021	The methodology implements a Smart Toilet System using Bluetooth Low Energy (BLE) beacons, integrating IoT devices, and wireless communication technologies for efficient public toilet management.	The innovative approach to urban public toilet management, integrating IoT and big data, holds promise for enhancing urban living. However, potential privacy concerns and technical challenges should be carefully addressed for successful implementation.
9.	Klaiwad Boonyakan, Naratsaporn Heamra, Attawit Changkamanon	2021	The study involved developing a smart toilet bowl system, using an ESP8266 microcontroller, infrared sensor for user detection, and a solenoid valve. Over 100 male users participated in three months of experiments.	The research presents a practical solution for water-efficient automated toilets using IoT technology. While focusing on male users in a specific context, it offers valuable information for the optimization of, flushing systems, emphasizing sustainability and user convenience.
10.	D Kristiyani, Dr. Sutomo	2021	The methodology involves collecting a diverse gender-annotated image dataset, developing a CNN-based facial recognition model, and conducting experimental analysis to evaluate accuracy and performance.	The study introduces a promising solution to enhance women's restroom privacy using CNN-based gender detection. While efficient, ethical considerations and cost implications require careful attention for responsible implementation in public spaces.
11.	D. Purkayasthaand G. Raheja	2021	The Scopus database was searched using keywords 'urban, public toilets.' Papers were screened based on subject areas, relevance, and consideration of overlaps, focusing on design, policy, and management intersection	The paper offers a holistic view of inclusion in urban public toilets in India, assessing global models. It urges context-specific studies, highlighting the need for nuanced solutions and applauds ongoing efforts.
12.	panelFernanda ,Deister Moreira, Sonaly Rezende, Fabiana Passos	2021	The paper systematically reviews the role of on-street public toilets, employing a comprehensive approach to identify gaps, raise awareness, and guide future research on urban sanitation.	This review underscores the indispensable role of on-street public toilets in urban sanitation, emphasizing the need for universal access to safe, inclusive spaces. The study advocates for further research and inclusive engagement guided by the United Nations policy framework.
13.	Emma Rary , Sarah M. Anderson , Brandon D. Philbrick , Tanvi Suresh and Jasmine Burton	2020	Systematic literature review, thematic analysis, biosensors in sanitation infrastructure.	The paper conducted a systematic literature review from 2000 to present on biosensors in sanitation infrastructure, identifying 21 relevant papers through databases like PubMed, Embase, Global Health, CDC Stacks, and NexisUni. It performed a reflexive thematic analysis to synthesize findings, revealing applications, strengths, and limitations of biosensors.

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14.	Raendran , R. Kanesaraj Ramasamy, Intan Soraya Rosdi , Ruzanna Ab Razak, Nurazlin Mohd Fauzi	2020	The study utilized an online survey with 124 participants, employing statistical analyses (descriptive, inferential) to examine user perceptions of the Smart Toilet system. Comparative analysis enriched the findings.The study employed an online survey with 124 respondents to analyze user perceptions of the Smart Toilet system. Statistical methods, including descriptive and inferential analysis, were used for data interpretation.	It is IOT based smart toilet and it evolves landscape based Smart Toilet systems, emphasizing user perspectives. However, it lacks detailed exploration of challenges, ethical considerations, and demographic insights.
15.	R Kanesaraj Ramasamy , Venushini Rajendran and Sevangthi Murthy	2020	The methodology involves identifying challenges, defining the project scope, conducting a literature review, sensor deployment, cloud-based data management, algorithm development, prototyping, testing, real-world deployment, continuous monitoring, feedback analysis, and comprehensive documentation.	The proposed IoT system for Smart Toilets offers promising benefits in optimizing janitorial resources through real-time data. However, potential challenges, including costs and privacy concerns, highlight the need for careful consideration and balanced implementation.
16.	Kirithika S Madhan Kumar L R Kingson Kumar M	2020	The methodology integrates hardware like microcontrollers, sensors, and software programming, employing technologies like infrared, ultrasonic, and biometrics to create a Smart Public Toilet System using IoT.	The IoT-based Smart Public Toilet System presents innovative solutions for sanitation, tourism, and disease prevention. However, challenges include potential technical failures and concerns about privacy, cost, and widespread adoption.
17.	Intan Soraya Rosdi , Ruzanna Ab Razak Nurazlin Mohd Fauzi	2020	The study involves literature analysis, Smart Toilet system design, prototype development, and user perception assessment through online surveys, employing the Theory of Planned Behavior.	The study offers a valuable integration of IoT in facility management. However, privacy concerns in IoT implementations should be addressed. The clear methodology ensures a systematic approach to system development and user perception evaluation.
18.	Andi Pramono , Tiara Ika Widia Primadani1 , and M. Aldiki Febriantono	2019	The methodology involves interviews, on-site surveys, and lux meter measurements to assess the restroom's conditions. It tailors a mechanical ventilation solution based on interview insights and uses technology, Arduino Mega, and sensors to automate electrical devices, aiming for energy efficiency.	It is IOT based smart toilet and it evolves landscape offering a comprehensive approach to address challenges. The integration of Arduino-based automation for energy efficiency is commendable, though scalability and long-term effectiveness need consideration for broader applicability.
19.	Ms. Nidhi R Mishra , Mr. Paras M Suri , Dr.(Mrs.) Shalu Chopra	2018	The methodology implements a Smart Toilet System using Bluetooth Low Energy (BLE) beacons, integrating IoT devices, and wireless communication technologies for efficient public toilet management	The paper introduces a technologically advanced solution for public toilet management using Bluetooth Low Energy (BLE) beacons. While innovative, it needs further exploration of BLE technology limitations and scalability concerns for practical implementation.

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IV. CONCLUSION

In conclusion, this research advocates for a transformative solution to the persistent challenges in public sanitation in India through the introduction of an Internet of Things (IoT)-based toilet monitoring system. The prevailing issues of inadequate facilities, open defecation, and poorly maintained public toilets underscore the urgent need for innovative approaches. Despite commendable initiatives like the Swacch Bharat Mission Urban, the lack of a centralized monitoring mechanism hinders the effectiveness of existing sanitation efforts.The proposed IoT-based system addresses this gap by leveraging advanced technologies, including a web server and a mobile cleaner application. By facilitating real-time tracking of cleaning metrics, the system establishes a dynamic feedback loop between cleaners and administrators, ensuring timely interventions based on user input. The system's novelty lies in its comprehensive features, such as automatic water flush, UV sanitization, and other advanced functionalities that collectively enhance the efficiency and sustainability of public toilet maintenance.With its potential for scalability and applicability across diverse settings, including homes, colleges, hospitals, businesses, and industries, the IoT-based system emerges as a practical and impactful intervention. By providing an economical and efficient solution, the system becomes a catalyst for positive change, offering a pathway toward cleaner and more sustainable public sanitation infrastructure. In essence, the proposed system represents a forward-thinking and practical response to the longstanding sanitation challenges faced by India, contributing to a healthier and more sustainable future.

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